IMPERIAL BUREAU OF PLANT GENETICS: HERBAGE PLANTS

BULLETIN No. 10.

GRAZING

PAPERS READ AT THE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AT LEICESTER ON SEPTEMBER 11th, 1933.

BY

P. F. ASTILL, William DAVIES,
M. G. JONES and A. BRIDGES.

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AGRICULTURAL BUILDINGS
ABERYSTWYTH
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GRAZING IN THE MIDLANDS.

BY

P. F. ASTILL.

COSSINGTON, LEICESTER, ENGLAND.

It was with a considerable amount of diffidence that I accepted the invitation to open this debate by reading a paper before the British Association on the subject of Grazing in the Midlands. Naturally, I approach the subject from the practical side, as a grazier, and shall leave the scientific aspect to those gentlemen who will follow me, and who are much better equipped to deal with it. I am conscious of my limitations, and it is by the encouragement of friends who have a higher estimate of my knowledge of the subject than I have, that I have undertaken to read this paper. My justification is the fact that I have had the management of pasture land for over forty five years.

Grazing the rich pastures of the Midland area means feeding animals, many for a comparatively short time, to fit them for the butcher. It is of secondary interest whether they have been reared on the poorer pastures of the farm or are brought from other districts; in the majority of cases they are purchased.

The grazier has to consider what type of animal is most suitable for his pastures, at what weight and age the finished animals, bullock or heifer, commands the best price. He must secure the number he required for the maximum growth period of his land, knowing that when the maximum growth is over he must have some of his cattle ready for sale.

These are the main facts the farmer must always have before him; if he disregards them, he cannot be successful.

What has produced these renowned pastures is of the greatest interest. Much land has been turned to pasturage in my time. Many fields have become good feeding land but have not reached the standard of the best old ones. The rich old pastures have been grazed for several hundred years; there is no record of how or when they were laid down, or that they have ever been manured. We all know they are on naturally fertile land, and that the climate, surface soil, and sub-soil have had an influence upon them; but these influences do not explain their feeding quality, for adjoining fields are often much poorer. I am absolutely convinced that it is management, 90 % management, perfect grazing, eradication of thistles, the movement of excessive dung from under trees and hedge-rows. No cattle are allowed to trample them in the winter; only sheep are grazed on them and continue in the early months of the year. In April a few cattle are turned out into the fields to eat the earliest growth; as the pasture improves more animals are turned in till the maximum number is reached from the 12th to the 20th May. I am reminded of an old adage, "Land will carry more stock in nine months than in twelve." It appears so foolish, but it is true. I should prefer to say, land will produce more live weight increase if rested for three months. The management of these pastures is an art in which only a few excel, and it is perfect grazing that is the beginning and end of their virtue. Their richness or strength had caused a difficulty, for only fully developed cattle are able to thrive upon them. This view is held so tenaciously and unanimously that it is dangerous to think it is a fallacy. I do not farm any of these special pastures so I have not been able to experiment on them, but my better fields give me reason to think the contention is true.

The grass feeds these cattle without assistance, but a young steer is so purged it does not thrive. Is the grass an unbalanced food or is there a deficiency? This is a subject for the expert, a question much too long unsolved. The public is demanding a younger and less heavy animal, and the feeding of these older, heavier, fully developed bullocks is wrong if it can be avoided, and I invite my scientific friends to demonstrate that it can be. I cannot think of any demonstration of greater value at the present time than one that will prove that younger stock can be successfully grazed on these rich pastures. For instance, a few fields might be rented

from the present occupier, and grazed with selected young stock, which have been carefully reared, and which have maintained steady progress from birth. Part of them should receive food to balance the pasturage, the others the grass only. Two or three older cattle would be grazed as a control. This would not be an expensive experiment, and it might prove of inestimable value to the grazier.

An efficient supply of water is of the greatest importance. Spring water should be conducted to a large trough, so that the temperature of the water will be raised in the hot weather. If the supply is from a pond, the pond should be fenced and the water conveyed by a pipe to a trough. This water, which is near the temperature of the day, I believe to be the best possible supply for cattle or sheep. An animal over-heated by disturbance of the gad fly on hot days is upset by drinking an excess of comparatively cold spring water.

I have been talking of the almost perfect pastures of the district. A few minutes may be usefully spent in considering how fields may be improved in feeding value. Efficient stocking is the first principle, but it breaks down in growing seasons when store stock reach a prohibitive price. When the pasture cannot be controlled by cattle feeding on it and when the grasses are likely to run to seed, it is advisable to use the mowing machine. This operation does not reduce the carrying capacity of the field for the season, in fact it increases it and prevents injury to the pasture in the following years.

On the poorer fields which may be stocked by younger animals or used as adjuncts to the best pastures, bunches of grass may be left, provided they are removed before the spring by winter grazing and strong tined harrows. Only fields which are properly grazed, that is where the grass is eaten as it grows, make the steady improvement which constitutes the feeding value of the pasture.

A matter of much interest and importance to the feeder of cattle and sheep is the changing taste of the consumer. He is demanding a much smaller joint, cold meat is "taboo," and he wants the joint to be as tender as possible. His requirements in mutton and lamb have been met to a very great extent. There are so many breeds of small sheep that the farmer has gone a long way in producing the size of joint required. The hill districts of England, Wales and Scotland continue to produce a good supply of suitable store sheep, and these hill farms cannot turn to any other mode of agricultural production, so the supply is assured. The production and rearing of the proper type of store cattle presents many difficulties. Milk production, the only section of agriculture which of recent years has not lost money, has attracted hundreds of rearers of store cattle and many arable feeders of cattle. The sire of the dairy herd is chosen with little consideration for the flesh-producing capacity of the animal. The loss of the arable acreage has reduced the capacity of the country to winter store stock, as well as the winter production of meat.

These changes are giving fewer stores, and of a quality not suited to meet the present requirements. There are reasons to hope that these conditions will become less adverse in the future. Milk supply is in excess of demand. The passing of the Improvement of Live Stock Act, 1931, which comes into force next year, will have a beneficial effect on the store stock of the country. We have associations of farmers joining together to secure bulls of merit, notably the Dragon Scheme in Wales, which cannot fail to breed an animal suitable to meet the present requirements, and will prove of great assistance to the grazier.

One of the worst difficulties of the meat trade and especially to the summer feeder, is the unequal production of both beef and mutton, caused by the tragic decline of the arable area. This reduces winter production, and increases the grass supply in the autumn to a quantity which gluts the market. There is a demand for high quality home produced beef at 2d per lb. above imported. This demand, unfortunately, is to a very great extent controlled by our small winter production, not by our large summer production. When, by small supplies, we force a purveyor of meat to buy imported it is difficult to get him back again to sell English.

The grazier is suffering, with all other branches of the industry, by the disturbed balance of agriculture. The Government is introducing schemes to stabilise agriculture, to produce more evenly, and to market better. All branches of our industry are in the closest touch with the Ministry in formulating schemes for the different sections, with the full knowledge that success can only be achieved if the whole is dealt with. The grazier is anxiously waiting for the report of the Commission which is dealing with the meat question.

If the grazing of the best pastures is to give a reasonable return to the grazier in the future, I believe the most important factor is to secure a stable price. To buy store cattle without any assurance of its finished value is a gamble rather than a business transaction. Stability of price is the first essential to success, how it is to be secured is puzzling the best brains in the country. Controlled sales to give an even supply may be necessary. Secondarily, other influences are rearing a type of animal more suitable to the present demand of the public, and a wider appreciation of the fact that the feeding value of the pasture is the measure of its management rather than any special value of the soil, or of the manures which may be applied to produce the pasturage.

In conclusion, I wish to say that farmers are more willing than they have ever been to listen to, and take advice from the experts who have, and are now, studying the scientific aspects of our calling ; but what must come first is a reasonable chance of our efforts meeting with some success. Against subsidised imported food farmers are helpless.

THE BIOTIC FACTOR : LESSONS FROM AUSTRALIAN AND NEW ZEALAND GRASSLANDS.

BY

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If it were possible to prevent the access of man and his grazing animals to the grasslands of the world, many of those grasslands would revert to some form of forest or scrub. The area of land under grass would thus obviously become restricted and in many regions grassland as we know it would disappear altogether. Such a statement is a truism in regions purposely deforested and now being maintained as pastures. Grassland of this type is therefore a direct reflex of the biotic factor imposed upon it, and may be regarded as a biotic climax. Studies made on areas of so termed "natural grasslands" suggest that these too may represent biotic climaxes rather than being functionary *only* to soil and climate. True, both soil and climate have had an important effect upon their development, particularly where, under arid conditions, the natural succession from vegetation of one type to another is a slow process. It is my belief that steppe and savannah grasslands are in fact true biotic climaxes developed under an extremely lenient form of grazing. They are biotic communities in harmony with a system of light grazing under climatic conditions that make for slow successional changes in the natural vegetation.

Grassland as a biotic community is an unstable vegetational phase. The part played by the grazing animal in maintaining such a community is possibly more obvious in newly-settled lands than it is in the older countries. Rapid transitions from one vegetation type to another are commonplace events: the transition from grassland to scrub consequent upon understocking, for example, in parts of New Zealand; or the change from grassland to desert induced by continued over-grazing in regions of low rainfall and prolonged drought.

Natural succession without the influence of the grazing animal is always towards the development of scrub and forest, while man is striving to maintain open country. By means of his firestick, his seed and manure bags, his mechanical cultivation and, most important of all, his grazing animal, man is striving to arrest the natural sequence towards wooded country and to maintain his land in grass and in crop. Man is undoubtedly winning.

Among primitive peoples the firestick was, and still remains, one of the most important instruments used for destroying forests and for maintaining open country where tribal cattle might forage in relative security. Within living memory important changes have been wrought upon the primeval vegetation of Australia and New Zealand. Subsequent to colonization by white people dense forests have been destroyed and grassland has been created in their stead. This has provided the wherewithal for carrying herds of cattle and flocks of sheep. From the economic standpoint, the change from forest to grassland has been advantageous—it has at any rate made possible a rapid increase of the number of livestock carried.

Consider for a moment another picture—namely, the naturally open country such as is developed under conditions of periodic drought—the steppe, savannah and savannah woodlands. While man has been clearing the great forests, consider what has happened to the open country. In Australia these open areas have been appropriately fenced, water for stock purposes has been conveyed to them, sheep and cattle have been foraged in ever-increasing quantity. In short, a new biotic factor has been imposed upon them, a factor to which the existing vegetation had never become attuned. Over-stocking has often taken place with the result that depletion of the existing vegetation has been brought about. Many of the original elements of those "pastures" have been eaten out, possibly never to become re-established.

In extreme cases depletion has been carried to such an extent that only ephemeral herbage remains. Where this has taken place, the savannah and steppe grasslands give way to desert. The point I wish to stress is, that if the balance of the existing biotic community is upset by the introduction of a new factor, such as grazing by domestic stock, which are of necessity limited to

specially enclosed areas, sooner or later this will be reflected in the botanical make-up of the vegetation. The more arid the conditions, or, *inter alia*, the greater the concentration of grazing animals, the more rapid are those vegetational changes likely to be.

That is not to say that introduction of stock is necessarily detrimental to the grasslands of semi-arid regions, nor that the changes which may be brought about in the vegetation need be harmful ones. I would stress that to maintain grasslands of the highest economic value the grazing must be adjusted in conformity with the demands of either the most desirable plants in the existing pasture, or of those which can be introduced to it. Scientific grazing, therefore, pre-supposes a knowledge of the reactions of pasture plants, and an effort to graze in accordance with the demands of the several sward constituents.

I will now indicate the type of grassland change which has been induced by different and sharply contrasting types of stock management in parts of the Mitchell grass steppe and savannah of Central Queensland. The area concerned lies in the tropics in the Longreach-Hughenden district just north of Capricorn, at an elevation of 500-1,000 feet. The average annual rainfall is from 12 to 17 inches mainly derived from summer monsoonal showers. The rainfall as a whole is erratic and badly distributed over the year. Day temperatures are high, the nights are cool or even cold, and dews are normally heavy.

The Mitchell grasses (*Astrebla* species) form the dominant herbaceous cover over wide tracts of this area. In the natural state there occurred in these grasslands various other grasses belonging to a number of genera. The natural covering was dominantly gramineous. The pastures are characteristically open and tussocky with a considerable proportion of bare ground between the plants.

The following observations were made* during an all too short visit to this region, at a time when drought of more than usual severity was being experienced.

The effect of differential grazing and treading upon grass steppe vegetation in Central Queensland (Longreach-Winton-Hughenden district).

Location.	No. of genera recorded.	Estimated total ground cover.	Dominant plants.
Railway line enclosure	12	50-70 per cent	*Astrebla* spp.
Typical paddocks	7	25-30 ,,	do.
Main stock route.	4	5-10 ,,	Miscellaneous herbage.
Town reserve (Hughenden)	3	Negligible (Occasional patches of vegetation locally covering up to 5 per cent of the ground.)	Non-edible shrubs.

The railways are fenced and reasonably stock-proof. The railway enclosure may, therefore, be taken to represent the natural grass cover to which grazing animals have had little or no access, at least since the railway track was laid. The herbage here covers from 50 to 70 per cent. of the ground in plan and at least 12 genera are represented. Of these genera nine are gramineous, namely, *Astrebla, Andropogon, Pollinia, Themeda, Iseilema, Aristida, Panicum, Pappophorum,* and *Chloris*. Families other than Gramineae are represented by *Xanthium, Rhagodia* and *Bassia,* which occur in small amounts. Noogoora burr, belonging to the first of these, is exotic, and is a troublesome weed.

*April 1932.

The fenced paddocks in the neighbourhood grazed in accordance with local practice have a ground cover of something like 25-30 per cent. Mitchell grasses (*Astrebla*) provide the main herbage ; occasional plants belonging to other grass genera are also to be found. The miscellaneous plants occurring in the railway enclosures also occur on the paddocks in approximately similar proportion.

The adjoining stock routes are heavily grazed and trampled by passing flocks of sheep ; the vegetation is in consequence considerably reduced. Among the Gramineae only specimens of *Astrebla* (Mitchell grasses) remain and a large proportion of the herbage to be found on these is inedible, or at best is of low palatability. In comparison with the natural vegetation a very marked and important increase in the weed flora has been induced by the heavy grazing to which the stock routes are exposed.

The town reserves of Central Queensland are situated normally at the confluence of stock routes or main roadways. Here we have an example of the influence of heavy grazing and frequent trampling (mobs of sheep would be rested overnight and sometimes for longer periods on these reserves). The Hughenden reserve at the time of my visit presented an almost complete picture of total depletion. Very few plants of any kind occurred except a few specimens of the unpalatable Darling pea (*Swainsona* species). Occasional plants of *Tragus racemosus* and *Sporobolus Lindleyi*—both ephemerals—were found.

From these observations we may infer that man and his Merino sheep have it in their power to deplete the valuable Mitchell grass areas of Central Queensland and to create desert conditions in their stead. The work published by Osborn and his colleagues concerning the Salt bush (*Atriplex*) steppe region of South Australia also shows that heavy grazing in which the rabbit has played its part is an important factor in the depletion of vegetation in that zone.

Man, if not himself the master factor in the development of the biotic community, exercises the controlling influence upon that community. Enough has been said to indicate the importance of the grazing animal upon grasslands. The animal is a factor of fundamental importance in the improvement or deterioration of any particular piece of pasture. The intensity of grazing, the length of the rest period between two consecutive grazings, and the type of stock used as grazing machines (defoliators)—each has a vital influence upon the botanical make-up of pastures ; each has a vital effect upon the individual plant, upon its productivity, its rate of recovery after defoliation, its persistency, its resistance to drought and other periods of physiological stress. The system of grazing, therefore, has a controlling influence upon the balance of sward constituents as a whole.

The rôle played by the domestic animal differs only from the effect of wild animals in so much as man exercises a greater degree of control over the former. The rabbit is an important element in the biotic community and one which by virtue of its large numbers, together with its capacity for extremely close defoliation, plays an important part in the destruction of grasslands, particularly in areas of low rainfall. The rabbit in relation to vegetation has been studied intensively by Farrow on the East Anglian Heaths ; by Osborn and his colleagues in semi-arid Australia, and by L. Cockayne in New Zealand. Uncontrolled rabbit invasion spells disaster to any grassland type. In semi-arid areas the close continuous defoliation of the existing gramineous and (or) shrubby vegetation causes depletion or even complete destruction of that vegetation, while the lessons learnt on the East Anglian heaths of Britain point to the same conclusions. Productive pastures in any given region or under any given set of conditions are impossible under a system of close defoliation continued indefinitely.

The kangaroo in Australia presents a completely contrasting type of grazing. In the wild state they would follow the patchy rains and any showers which would provide them with a green bite of herbage. Kangaroos, therefore, are essentially intermittent grazers. Any particular piece of vegetation would be allowed a more or less lengthy period of rest after each grazing, during which time the kangaroos would have moved off to fresh pastures. A very different state of affairs is set up when fences are erected by man, and when sheep and cattle are penned on to specific areas of these grasslands. Domestic stock confined to those areas have to be content to forage what they can, irrespective of their influence upon the pasture complex.

It is important to note that while the grasslands of these semi-arid areas may be capable of standing up to periodic heavy grazing under a definite scheme of rotation, they are not attuned to continuous heavy defoliation. Our knowledge is scant regarding the possibilities of introducing new species of plants into these pastures. We can, however, learn how to preserve the more valuable components of the natural vegetation and to encourage their growth and their spread by more enlightened methods of grazing and of livestock control. It is probable also that by periodic resting on a well planned and knowledgeable basis already depleted areas can be regenerated; such at least are the indications given by a study of semi-arid Australia.

I have attempted to lay emphasis upon the influence of fauna upon flora—in parenthesis one might indicate that the influence of flora upon fauna is likely to be equally marked. We may now proceed to analyse the principles which underlie pasture improvement. The problems will be discussed briefly from four major viewpoints, namely:—

1. A consideration of Linnean species.
2. A consideration of strains and (or) types within the species.
3. A study of soil fertility and its relationship to sward type.
4. Grassland management in its wider sense.

SPECIES AND STRAINS. Whether we are concerned with pasture creation or with pasture improvement, the problem which presents itself is similar in nature, namely, that of finding suitable species of pasture plants attuned both to the local conditions of soil and climate, and to the biotic factor in terms of the grazing animal: attuned that is to the influence of successive defoliation together with more or less short intervening rest periods.

The efficient pasture plant must be able to recover after grazing and to maintain as high a rate of recovery as possible after each successive grazing period.

It is impossible to deal adequately with the problems of species without having regard to the question of strains within the species. Wide varietal differences occur within every species so that when a species is known to be of value in any particular environment, further study must necessarily have regard to existing strains. Where the species is of fundamental importance as, for example, perennial rye-grass and white clover on the grasslands of Britain, then the production of entirely new strains may be necessary. There is now no doubt that plant breeding and genetical methods can be used successfully and to advantage upon herbage plants. The researches being conducted at Aberystwyth have shown the immense possibilities of detailed investigation into the problems of strain in our own more important pasture species. Work of a similar character is being conducted in both New Zealand and Australia. The New Zealand work has made important advances during its preliminary stages; the results are already being commercialised and are therefore likely to affect our agriculture here in Britain in so far as special forms of rye-grass, cocksfoot, white and red clover may be exported to this country. It is for us in Britain to decide on the basis of critically conducted trials, whether or not the New Zealand strains are suited to our special requirements. It is almost certain from the results of trials at Aberystwyth that New Zealand certified white clover could with advantage replace the bulk of our yearly purchases of European white clover. Similarly the best type of New Zealand (Akaroa) cocksfoot shows considerable superiority over the Danish strains when grown in Britain.

SOIL FERTILITY. Artificial manuring has made possible fairly sharp changes in grassland types. Of particular significance in this connection is the increase in the clover: grass ratio promoted by the use of phosphates.

A method of soil improvement of particular significance in newly developed countries is the utilisation of pasture legumes as pre-crops with the special design of promoting a higher standard of soil fertility. On some of the soils of temperate Australia, for example, the maintenance of pastures in which subterranean clover is a dominant constituent becomes not only an end in itself—these rich clover pastures are highly profitable in comparison with "natural pastures"—but a luxuriant growth of subterranean clover, maintained for a few years, altogether alters the soil condition. The habitat is changed from low fertility to one of high fertility in which high class perennial grasses can be maintained. Phosphates are essential to the luxuriant development of the clover and are, therefore, fundamental to the successful change-over from one

fertility standard to another. We, in Britain, can draw a useful lesson from the Australian experience with subterranean clover—precisely in fact the lesson that Jethro Tull taught us in regard to enriching our soils with clover root. It is doubtful if in a grassland sense we have taken sufficient cognisance of the Tull doctrine. There can be no doubt that building up soil conditions by means of clover is essentially sound practice, and we have the strains whereby this can be accomplished in this country. In this respect our own native wild white clover is a pre-eminent soil improver. As in Australia, and as in New Zealand, so in Britain—phosphates are an essential adjunct to successful establishment and maintenance of a vigorous clover root. I have already spoken of high fertility demanding and low fertility tolerating species. These terms obviously are relative and rather ill-defined. Detailed investigation is necessary before the terms can be given proper definition and before our common grassland species can be adequately classified on the basis of fertility requirements. I would stress that different species of herbage plants differ in the demands made by them upon soil fertility, and are amenable to classification on that basis. It is a matter of common observation that our best soils will stabilise as grasslands at the perennial rye-grass-white clover standard, that is to say, perennial rye-grass and white clover make dominant contribution to the herbage. In the same way certain of our poorer soils stabilise naturally to an *Agrostis*-fescue type characteristically deficient in clover, while some of the very poor hillside soils in Wales and other districts of high rainfall in Britain will stabilise as *Nardus-Molinia* moorland.

MANAGEMENT. The manner in which stock graze upon grassland is an important factor influencing the stability of that grassland. Emphasis has been laid upon this aspect throughout the earlier portion of this paper, and an endeavour has been made to show that grassland will stabilise at different points in conformity with the type of management imposed upon it. Under conditions of periodic drought it has been shown that continuous hard grazing will cause either partial or complete depletion of the existing herbage. The close hard grazing by rabbits on the natural pastures of semi-arid Australia has been causative of depletion in these areas.

On our own grasslands in Britain we can only maintain the proper balance of species if we direct our grazing so that desirable species are afforded exactly those conditions conducive to their vigorous development. We can start off with a uniform field, divide that field into a number of folds, and impose upon each of these a different type of grazing. As a consequence we are likely, nay certain, to get reactions closely related to the grazing technique. Close continuous grazing promotes a short herbage where flat-weeds dominate. At the other extreme, undergrazing continued for any length of time favours the growth of tall perennial grasses and weeds. If undergrazing be continued indefinitely, reversion to coarse herbage and ultimately to scrub and forest will take place. Over large areas of Britain pastures are heavily grazed in early spring and badly understocked during the summer and autumn. This tends to spoil pastures in so far as the valuable early growing grasses are discouraged while those species which do not start growth until the late spring flush are favoured.

The road to effective sward maintenance lies along the middle course, that of controlled intermittent grazing at all times of the year : the length of rest period and the intensity of grazing are determined by the pasture type concerned and by the demands of the species desired to encourage.

In this short survey I hope that one point is made clear, namely, that the technique of grazing will always be reflected in the botanical composition and the productive capacity of any given piece of grassland. This is the one thing in particular which is learned from the study of grasslands overseas ; it can equally thoroughly be learned from our own grasslands at home.

The principles of intermittent or controlled or rotational grazing—call it what you will—are just as applicable to pastures in semi-arid areas as to those of Britain. Characteristically, however, the tendency in Britain is to understock the pastures during summer when growth is most active. The opposite tendency is apparent in regions of low rainfall, namely, to increase the stock to a higher point than the natural pastures can tolerate. One of two alternatives will have to be followed in such cases, either the biotic factor must be adjusted to the demands of the natural grasses or a new complement of plants will have to be found which have the ability to withstand rigorous grazing under the prevailing climatic conditions.

To sum up, let us take heed of how best to regulate the biotic factor and grassland can give both pleasure and profit.

THE ART OF GRAZING AND ITS EFFECT ON THE SWARD.

BY

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Pastures generally contain a number of different species and strains of plants which are in continual competition with one another, yet within the British Isles there are several distinct types of pastures characterised botanically by the preponderance of some one or two particular constituents. Some of these types occur only in localised districts whilst others have a more general distribution. The texture of the soil and its general level of fertility together with the climatic conditions have usually been considered to be the chief controlling factors in determining the botanical development of such swards.

In order to ascertain the influence of the biotic factor as controlled by man, a series of experiments have been conducted at Jealott's Hill. Starting in each case with a uniform area of pasture, distinct changes in the flora according to a preconceived plan have been induced by varying the time and intensity of stocking.

In deciding the broad principles to be followed in encouraging the clover in one plot and the grass in another, the guiding principles were :—

(a) that there is a difference in habit of growth between perennial ryegrass (*Lolium perenne*) and wild white clover (*Trifolium repens*). The stem of the clover grows in a prostrate manner on the ground, while the perennial ryegrass has a more erect habit of growth ;

(*b*) perennial ryegrass starts active growth early in the spring while wild white clover is very much later ;

(c) it has been found that hard grazing of a plant at the time of the commencement of active growth in the spring has a very marked weakening influence on that plant, an influence that is expressed throughout the rest of that growing season by a less robust plant.

Four plots were fenced off on a young clover-dominant sward sown down two years previously with a comparatively simple mixture :

Perennial ryegrass (Kentish indigenous)	24 lb. per acre.
Rough stalked meadow grass	6 „ „ „
Wild white clover (Kentish indigenous)	2 „ „ „

The grazing was controlled as follows :—

Plot 1 was intended to become still more clover-dominant and was therefore stocked heavily throughout the grazing season, particular care being taken that the pasture was very closely grazed during the months of March, April and May. The result of this method of stocking was that the perennial ryegrass suffered during the critical period in the spring to such an extent that it was in a rather weak state throughout the rest of the growing season. The wild white clover, on the other hand, suffered very little from the close grazing, and at the same time benefited from the reduction in the competitive influence of the grass ; by the middle of the third season it had become the most important constituent of the sward (Table 1).

TABLE 1.

EXPERIMENT 2. JULY 1933.

	Percentage Composition of the Sward.		
	Lolium perenne.	*Trifolium repens.*	*Agrostis* and *Holcus lanatus.*
NITROGEN AND PHOSPHATE.			
Plot 1	32	**62**	.2
2	**84**	6	5.3
3	54	38	1.6
4	39	42	**9.7**
PHOSPHATE ONLY.			
Plot 5	31	**61**	.8
6	**77**	9	7.0
7	59	30	3.3
8	37	45	**9.2**

Plot 2 was on the contrary intended to become more grass-dominant ; it was not grazed before the middle of April and from then onwards was never grazed very closely. Here the perennial ryegrass attained to such a vigorous state in the spring that it did not suffer much from the subsequent grazing . By the end of May, when the wild white clover was about to commence active growth, the ryegrass was already so dominant in the sward that the wild white clover was considerably checked and remained so throughout the rest of the season (Table 1).

Plot 3 received an intermediate treatment in that it was not grazed before the middle of April, but at each subsequent grazing it was completely bared down and then rested for about a month. Here the perennial ryegrass benefited from the early spring rest, but the close grazing which followed at monthly intervals gave the wild white clover an opportunity to compete fairly successfully, with the result that a good balance was maintained between the grass and clover in the sward (Table 1).

Plot 4 was subjected to a method of grazing which is all too common in many of our grassland areas, namely, a fixed rate of stocking per acre regardless of the amount of growth produced at the various times of the year. In this case, the stocking was increased in summer to about twice the winter rate, although the growth per acre in June would probably be more of the nature of twenty times that in January. In other words, this plot was overstocked in winter and early spring and grossly under-stocked during the summer and autumn. Although such treatment assisted the spread of wild white clover, it reduced the early grass and at the same time allowed the least valuable or worthless grasses—*Agrostis* spp. and *Holcus lanatus*—to increase, thereby producing a distinct deterioration in the botanical composition of the sward (Table 1).

The above four plots had all received a dressing of phosphate at the commencement of the experiment and a dressing of nitrogen in the spring of each subsequent year. For comparison four plots (Nos. 5-8) on an adjacent area of the same sward, receiving only the phosphatic dressing, were stocked in such a way as to correspond respectively with the first four plots. As shown in Table 1, the botanical differences obtained between the plots in the second series were very similar to the first series, thus showing that the method of grazing had a greater influence than the manuring on the botanical composition.

In order to see whether such principles would hold in dealing with an old permanent sward, a similar series of eight plots were treated in a corresponding manner, both in regard to manuring and grazing. As shown in Table 2, there was a rapid increase in clover content on plots 1 and 5, whilst at the other extreme, plots 4 and 8 retained their high proportion of the poorer grasses, namely *Agrostis, Holcus lanatus* and the fine-leaved fescues (*F. rubra* and *F. ovina*).

TABLE 2.

EXPERIMENT 6. JULY 1933.

	PERCENTAGE COMPOSITION OF THE SWARD.		
	Lolium perenne.	*Trifolium repens.*	*Agrostis, Holcus lanatus* and *Festuca* spp.
NITROGEN AND PHOSPHATE.			
Plot 1	26	**53**	12
2	25	17	55
3	33	25	33
4	3	3	**86**
PHOSPHATE ONLY.			
Plot 5	27	**49**	16
6	19	15	56
7	20	20	50
8	2	6	**82**

The ~~influence~~ inference is that even old pastures which have attained to a point of equilibrium with their environment many years ago can soon be changed by altering the system of grazing.

In a third experiment such variations in management were extended in order to differentiate not only between the proportion of clover to grass, but also to discover whether more closely allied species such as perennial ryegrass and cocksfoot (*Dactylis glomerata*) would be influenced by different times of stocking. For this purpose another young sward containing very little clover, but with a fair mixture of ryegrass and cocksfoot was utilized. This experiment was conducted on very much the same lines as the first, with one exception. In order to encourage the ryegrass at the expense of the cocksfoot, plot 2 was rested throughout March and the first half of April when the ryegrass was making its initial growth, and was grazed from the middle of April onwards, a period corresponding with the first part of the season's growth in cocksfoot.

TABLE 3.

EXPERIMENT 3. JULY 1933.

	PERCENTAGE COMPOSITION OF THE SWARD.			
	Lolium perenne.	*Dactylis glomerata.*	*Trifolium repens.*	*Agrostis* and *Holcus lanatus.*
NITROGEN AND PHOSPHATE				
Plot 1	16	8	**70**	2.1
2	**41**	34	19	3.3
3	7	**84**	5	2.8
4	19	33	18	**11.1**
PHOSPHATE ONLY				
Plot 5	28	9	**53**	1.2
6	**45**	28	18	3.6
7	13	**76**	6	3.0
8	27	15	32	**17.2**

Plot 3, on the contrary, was grazed during March and the first half of April in order to check the perennial ryegrass, but from the middle of April until the middle of May, when cocksfoot was making its active growth, the plot was kept free from stock. By the third season (Table 3) the cocksfoot had attained an almost complete supremacy, both under the nitrogen and phosphate treatment and under the phosphatic manuring alone.

Plots 1 and 5 also showed that a sward almost devoid of clover at the beginning of the experiment could be converted in two seasons, given suitable management of the grazing, into a clover-dominant sward.

Indeed this shows that the method of stocking had a greater influence on the botanical composition of the sward than even the original seeds mixture sown.

A statistician might criticise these experiments on the lack of replication of the individual plots. The differences between the plots receiving the various grazing treatments are however so great, and moreover, they persist right up to the boundaries of the plots, so that when the three experiments are taken together, in conjunction with the two halves in each experiment—the nitrogen and no nitrogen series—there can be no doubt as to the significance of the results.

The foregoing experiments dealt in the main with differences in the management of pastures in the early part of the season. There are just as important differences to be seen on investigating the management during the later part of the season—in the autumn. Protection from the early autumn onwards favoured the development of cocksfoot whereas with late autumn protection the ryegrass became dominant.

Considering the bearing of the experiments on the type of pasture found in various districts, it will be seen that the heavy stocking of Romney Marsh in the summer is conducive to the development of wild white clover; their protection or very light stocking in early spring and again in September would tend to make perennial ryegrass dominant over such other grass competitors as cocksfoot.

In the famous Midland pastures, the best pastures are allowed to make a good start in the spring before the stock are turned in, thus encouraging the early grass—perennial ryegrass. Being noted as a feeder who would fatten every beast off grass before the winter, the Midland grazier does not, however, stock so heavily during the summer months, especially after he commences selling stock in July. The tendency is therefore for *Trifolium repens* to become less dominant, with in some cases an undue increase in the proportion of *Agrostis* spp.

In parts of Northumberland which are now gaining a reputation for their wild white clover pastures, the feeder buys his store cattle not in the spring market, but in the relatively cheaper summer period; the pastures are stocked to their full quota throughout the summer and autumn, thus encouraging the wild white clover and checking the unpalatable bent grass. In those very same regions of Northumberland one finds some of the purest swards of cocksfoot under similar conditions of soil and climate. These are the paddocks into which the stock are usually turned for a month or two in the autumn when the "feeding pastures" are due to be unstocked, and which are again utilized in the spring to acclimatize the cattle before the "feeding pastures" are available for stocking about the middle or end of April.

In conclusion it may be emphasized that there is more than one species in every pasture, that those species grow in competition with one another and that it is largely for the farmer to decide by his management of the grazing which shall be the dominant species.

SOME ECONOMIC ASPECTS OF GRASSLAND.

BY

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Since 1867 when agricultural statistics for England and Wales were first published, grass has been the most important crop in the farming of this country. Nevertheless historically grassland farming has never been regarded with any enthusiasm. Orr has said " men who speak and write about agriculture praise the plough . . . . When they want to tell a tale of woe they speak of the increasing area of land being ' laid away ' to grass . . . . turned from a state of activity to one of inactivity."*

The abased position of grass is mainly psychological. Grassland farming has none of the glamour which belongs to arable farming. The pride in well-bred stock seldom extends to the grass on which they live. The association of grassland with a so-called inferior type of farming arose also from the claim that the expansion of grass at the expense of ploughland led to a diminished employment on the land. It is doubtful, however, if this is the correct, at any rate the only explanation of the diminished employment on the land since the eighties of last century. The actual work involved in the management of an area of grassland, whether in the form of grazing or hay, is no doubt considerably less than that required for a similar area of ploughland in general mixed farming ; but since the outstanding development in grassland farming in England and Wales was in milk production, the additional labour required for the cows, as compared with bullocks or sheep, must have helped considerably to compensate for the loss involved in the change from arable to grass.

Further when we remember the great advances made in the mechanisation of arable land processes and the potentialities for the displacement of labour by machinery in this type of farming, we may feel much better disposed to the relatively steadier employment which grassland and its associated live stock gives.

There is no statistical evidence to show whether the extension of the grassland area increased or diminished the total production of the land. In reference to Scottish agriculture, Sir Robert Greig has stated " It is probable that the total production of Scotland in spite of the decrease of arable land is greater now (November 1930) than it was fifty years ago."†

But, whatever may have been the comparative value of the production of our agriculture under arable as compared with grassland farming, no one will deny that the extension of grassland, either in a permanent or temporary form, and the accompanying increase in livestock, was the means by which British farming was gradually brought in 1914 to a state of prosperity which had been unknown since the golden days between 1853 and 1876.

Since the Great War the problem of grassland has received considerably more attention than formerly. The recognition that grass is a crop just as any of those of the arable land has given a new outlook to scientific work and thought on grass. The work begun by Somerville at Cockle Park with slag and wild white clover and followed in practice to a remarkable extent has stimulated much other work on manurial problems of grassland. Recent experiments have suggested that nitrogen is a weak link in the manurial chain and that from its application may be expected a greatly increased production of leafy herbage of high protein content. Other weak links in the chain of general management of grassland have been pointed out. Over-manuring with farmyard manure has been common in the intensive milk selling areas of Lancashire, Cheshire and the West Riding of Yorkshire and is being remedied by theuse of lime and suitable artificial manuring. In many places ploughing and re-seeding has been found to be necessary for active growth and the economic use of fertilisers. For

*Orr, Grass and Hay Farming. Manchester University Press, 1931, price 1s.

†Sir Robert Greig. The Extension of Temporary Pastures in Arable Farming. Journal of the Farmers' Club, November, 1930.

much the same purpose, hoof cultivation as in the case of the Hosier system of milk production, the folding of poultry and, occasionally of pigs, on pasture, are recommended as other methods of making the soil do its work better and thereby improving the output or reducing costs.

In its protein stage grass has been found to be the equivalent in value and digestibility of linseed cake. Close grazing has been advocated because it prolongs the period of high quality of the grass and suppresses weeds, which lower the productivity of pastures to a very large degree. The intensive grazing system has its advocates and is being tried out. Lately the idea of working on a rotation with grassland has been suggested in order to spread production more evenly over the year. The advantages of early mowing on the quality of the hay have been stressed. Work on the preservation of surpluses of grass at periods when growth is most active is also receiving much attention. The greatly increased value of the seed of pedigree strains over commercial strains and of indigenous over 'foreign' strains has been shown by Stapledon.

In the use of machinery also the post-war period has seen some notable advances. The motor tractor, the sweep, and the stacker are in common use in our hay fields.

In a period of rather less than 12 years a vast amount of knowledge has been gained in relation to the management of grass and placed at the disposal of farmers if they have the wish and the need to use it.

The reasons which have prompted this attack on the grassland problem are to be seen in the greatly increased area under the crop since the end of the war. In England and Wales. on the average of the years 1912-14, there were rather more than 16 million acres of permanent grass and nearly 2½ million acres of temporary grass. As the result of the war the area of permanent grass dropped to 14,668,000 acres in the period 1921-23, while the area of temporary grass remained about the same. Since then the area of permanent grass has increased steadily, and by 1930-32 the area fell short of the 1912-14 figure only by some 300,000 acres. In the post-war period there was a slight falling off in the area of temporary grass, but the figure of 1930-32 is slightly in excess of that of 1912-14.

In thirteen counties of England selected as representing widely different climatic and economic conditions, viz. :—Suffolk, Norfolk, Bedford, Northumberland, Durham, Northampton, Oxford, Lancashire, Cheshire, Shropshire, Hereford, Cornwall and Devon we find that comparing 1930-31* with the period 1921-23 there has been an increase in the area of permanent grass in every case, the increase being particularly large in Bedford, Northampton, Oxford and Devon. During the same period the position of temporary grass has been much more variable, gains being observed in Suffolk, Durham, Oxford, Cornwall and Devon—the latter being particularly large—while declines are shown in Norfolk, Northumberland, Lancashire, Cheshire and Shropshire, and the remaining three counties Bedford, Northampton and Hereford show no change. Viewing the total of permanent and temporary grass in this period every county examined except Lancashire, in which there is a small decline due to a decrease in the temporary grass area, shows an increase, which is specially marked in Suffolk, Bedford, Northampton, Oxford, Shropshire, Hereford, Cornwall and Devon.

Comparing the years 1912-14 with 1930-31 the combined area of permanent and temporary grass in the latter period has passed the former total in 6 of the 13 selected counties. These are Suffolk, Bedford, Northampton, Oxford, Shropshire, Cornwall and Devon. This result is due mainly to an increase in permanent grass in the first five counties. In the South Western counties it is due to an increase in temporary grass. Of the selected counties the only one to show an appreciable decline in the grass area of 1930-31 compared with 1912-14 is Lancashire.

Perhaps the most significant feature of the change in the post-war period in England and Wales is the very large increase in the area of rough grazing. In 1921-23 the area was 4,798,000 acres—an acreage in excess of the pre-war figure—and in 1930-32 it was 5,321,000, an increase of 523,000 acres or nearly 11 per cent.

This large expansion of the rough grazing area is mainly the result of the unprofitable nature

*Figures for 1932 for individual counties were not available when figures were extracted.

of arable farming since the war, as large increases are particularly noticeable in East Anglia and in the chalk counties, where land has been allowed to 'tumble down' to rough grazings.*

The increase in the area under grass and rough grazings is the result of at least two tendencies. Firstly, it is the complement of the increase in live stock which has taken place since the war. Live stock and livestock products have offered better opportunities for making profits than arable land produce and, as a means of providing the necessary food for the stock, grass has probably been cheaper than the alternatives grown on arable land.

The numbers of the various classes of live stock in England and Wales since the war is shown as follows :—

TABLE 1.—NUMBERS OF LIVE STOCK AND AREA OF GRASSLAND IN ENGLAND AND WALES.

(In thousands and thousand acres.)

Period.	Cattle.	Sheep.	Horses.	Pigs.	Poultry.	Total Temporary or Permanent Grass.	Rough Grazings.
1912-14 ..	5,812	17,481	1,402	2,360	29,026†	18,475	—
1921-23 ..	5,687	13,702	1,335	2,472	24,816	17,152	4,798
1926-28 ..	6,185	16,773	1,081	2,621	38,657	17,735	5,122
1930-32 ..	6,090	17,514	939	2,758	52,737	18,167	5,321

†1913.

By 1930-32, cattle, sheep, pigs, and poultry had surpassed the pre-war numbers. Only the number of horses shows a decline, which is associated partly with the reduction in the arable area and partly with the substitution of tractors for horses. It will be seen also that the numbers of stock and the area of grass have moved in fairly close relationship to each other.

Secondly, while it is true that the main purpose of the increase in grass area was to pursue a livestock policy, I do not think that this was the only reason. The increase of the rough grazing area, which has come mainly, perhaps entirely, from the arable area cannot be taken as signifying a desire to increase live stock, but may be regarded as a means of curtailing expenditure on unprofitable land in a time of depression.

There are probably several reasons which may be offered to explain the lack of any livestock activity on these lands. From a farmer's point of view a change from arable to livestock farming would require the expenditure of capital in live stock and perhaps the sacrifice of capital in equipment, hitherto used in arable land operations. But even assuming he were able financially and otherwise willing to furnish the live stock there are other capital expenditures to be considered. The land often requires fencing, the laying on of water and the provision of buildings and permanent equipment for stock. But if much of this land would make unsatisfactory pasture land even with the best treatment, the landowners and the farmers themselves may doubt the wisdom of sinking long-term capital in this way, preferring to wait for a turn in the wheel of agricultural fortune.‡

So much for the new grassland which has resulted from the war or from the post-war economic conditions. Though we may deplore the fact that much of this is unsatisfactory from the point of view of good grassland, we must recognise that there may be sound reasons for a policy of inactivity at the present time.

Turning now to the old grassland, which is in poor condition, its improvement creates economic problems very similar to those just discussed. There is however one distinction that may be made. With a turn of the wheel of fortune in favour of arable crops, there is a

*An Agricultural Atlas of England and Wales. (2nd edition revised.) Prepared by M. Messer on behalf of the Agricultural Economics Research Institute, Oxford. Ordnance Survey Department, Southampton. Price, 10/-.

‡Improvement along these lines has of course been carried out, for example, by Hosier and others.

possibility that some of the post-war grazing land may again be profitable in arable cultivation, whereas this is a very unlikely possibility with the poor grassland which has not been in cultivation in this century. The problem therefore is simpler since it resolves itself merely to a consideration of the possibilities of improving its use for live stock.

Mr. Bligh's successful experience in Wales* has shown that, with the necessary technical ability and financial resources, the improvement of poor grassland can be made financially successful. There may be other examples no less striking, yet little headway appears to be made although Mr. Bligh has estimated that there are 1 to 1½ million acres of grazing land in Wales, and 1 million acres in the West of England which could be improved without going beyond economic limits.

There are some aspects of the question on which I might briefly touch. In the consideration of the profitableness of improving poor grassland, it is necessary to consider the costs and returns of alternative sources of supply of grass. It may for example be more profitable to force an increased supply of grass from better class grassland than to spend much money in improving poor grassland. The response in point of time may also be quicker and be an important consideration. In this connection Bond, in his paper to the Farmers' Club, indicated that progressive farmers will not touch poor grassland. They " prefer to exercise their talents and to apply their capital on farms elsewhere, which are immediately suitable for good quality live stock and which do not require large preparatory expenditure."†

We have to remember also that arable land is a potential competitor in the problem of improving grass. So long as there is arable land which is barely profitable under crops, there is always the temptation to lay this down to grass rather than to improve some existing grassland.

Perhaps equally important is the fact that unimproved grassland may have special functions in a system of farming, and to change its class by improvement might be desirable only if it was contemplated to change or modify the type of stock farming at the same time.

One of the greatest hindrances to grassland improvement lies in the inability to forecast the value of the improvement. According to Prewett, in his account of Mr. Bligh's activities, " the land improver requires to know the probable output of green grass per acre of the land under existing conditions and the probable output of green grass after improvement in the form of enclosing, bracken cutting, phosphating, draining, re-seeding, etc.‡

Grassland improvement, without probable quantitative results as a basis for estimating financial returns, becomes a speculation purely and simply. The technique of grassland improvement is becoming better understood and examples such as those of Mr. Bligh are of great value in estimating probable costs. The increased amount of attention which is being given to grassland problems by Research and Advisory Centres should in time give the necessary information on probable output, including some idea of the expected life of the improvement, and thus help to remove some of the risks attendant on the investment of money in grassland improvement.

The financing and carrying out of grassland improvement is largely a matter for landowners and there are many difficulties associated with its execution, as well as the lack of capital resources in landed estates to-day. On farms where there is grassland capable of improvement a landlord has not only to get access, but he has to convince the tenant of the extent of the improvement and to be able to extract from him the cost of it by way of an increased annual rent. Such an expectation depends on whether the tenant will be able to make good use of the improvement, i.e., he must have capital to stock the land or he must be able to reduce his present costs in some way or another. Generally speaking the combination of available capital in the hands of landlord and of tenants is a necessity. But Bond states that many of the farmers on poor grassland are already impoverished. In Mr. Bligh's improvements he took possession when land became vacant. Opportunities for getting possession of land for the purpose are not frequent and the process of improvement in this way must necessarily be a slow one.

Obviously, investments in the improvement of grassland will have greater chances of success when money is cheap or alternatively when the prospects for livestock farming are reasonably good.

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*The Improvement of Upland Grazing. Bligh and Prewett. Oxford University Press. Price, 1/6d.
†Bond, J. R. Improvement of Grassland, Journal of the Farmers' Club, May, 1933.
‡Bligh and Prewett. op. cit.

The ideas advanced since the war on the subject of the general management of grassland have raised many interesting problems in the mind of the farmer. I think I am right in saying that the general trend of the work on grassland management has been in the direction of getting an increase in the output of grass ; of obtaining an improvement in the quality of grass and hay ; and in changing the distribution of the supply throughout the year.

The improvement of the output of grass proceeds on two assumptions either that it will enable a larger head of stock to be carried or that it will be possible to curtail the expenditure on other food stuffs, both of which are probably economically possible on a great many farms in this country. Before proceeding to discuss this it might be well in passing just to remember a warning which Wyllie gives in a recent report. Emphasising the importance of preserving a balance between grass and stock, he cites a case where a farmer fully alive to what might be done to his pastures is unable to take any action because he has not sufficient stock. Wyllie says of this case " the first step to bring about a better balance between grass and stock is not the application of fertilisers but a greater capital investment in livestock."* This is a warning in passing which we must bear in mind as the situation may be more widespread than is usually accepted.

The economics of the problem of grass and hay versus purchased food depend on whether the expenditure involved in getting the increased output will keep farm costs of grass and hay inside the costs of foods obtained from other sources. Orr has given me two examples where, by the use of artificial fertilisers on grass land, the cost of feed and fertilisers per cow has been reduced in one case from £21 to between £11 and £12 per cow and in the other from £23 to £13 per cow. These are striking differences.

I am not sure how the saving arose, but the economies made in these two cases would seem to indicate that the costs of production of grass and of hay are very much lower than the cost of similar quantities of purchased or of home-grown foods. I have therefore made some calculations, which are shown in Table II, of the cost per unit of starch-equivalent of six foods, which are commonly purchased, and of grass, hay and mangolds.

TABLE II.—VALUES PER UNIT STARCH EQUIVALENT OF CERTAIN PURCHASED AND HOME GROWN FOODS 1924—1931.

	Starch Equivalent.	1924.	1925.	1926.	1927.	1928.	1929.	1930.	1931.	Aug. 1933.
A.—PURCHASED FOODS. (Less manurial values.)		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Linseed cake (12% oil) ..	74	3 5	3 6	3 2	3 1	3 4	3 6½	2 10	2 3	2 1
Cotton Cake, Egyptian (5% and 4½% oil) ..	42	3 4	3 3	2 5	2 8	3 5	3 2	2 0	1 11	2 1
Decorticated Ground Nut Cake (7% oil)	73	2 3	2 3	2 7	2 8	3 2	3 0	1 11	1 9	1 8
Palm Kernel Cake (6% oil)	73	2 2	2 3	1 10	2 3	2 7	2 8	1 9	1 7	1 6
Barley Meal	71	3 4	3 3	2 9	3 2	3 2	2 9	1 11	1 10	1 11
Maize Meal	78	2 10	2 10	2 3	2 3	2 10	2 7½	1 11	1 5	1 4
B.—HOME GROWN FOODS. (Before deducting manurial values.)										
Grazing†	11	0 8	0 9¼	0 9	0 7	0 7	0 6½	0 7½	0 7¼	
Meadow Hay	37	1 2	1 3¼	1 4½	1 6	1 9	1 7	1 5	1 2½	
Seeds Hay	38	—	—	—	2 0½	2 3¾	2 3¾	1 10½	1 7	
Mangolds	7	2 1	2 6	2 3	2 2½	2 2	1 10½	1 8	1 7	

†1924-26 from Leeds. The cost of production per acre of grazing in each year was as follows :—

1924—44/8. 1927—38/5. 1930—41/1.
1925—51/10. 1928—38/9. 1931—40/0.
1926—49/0. 1929—35/5.

All other costs are from Oxford.

*Wyllie. Hay Crops and Grazing. 1924 to 1931. South Eastern Agricultural College, Wye. Price, 1/-.

The starch equivalent values of the purchased foods are based on the average prices of the foods for the year, plus a uniform addition of 10/- per ton for carriage and less the manurial values of the foods. In the case of home-grown foods the figures represent the *net* cost of production of the commodity as taken from cost accounts. For example, in arriving at cost of hay the estimated value of the aftermath is deducted and in the case of the roots the value of cultivation and manures which are presumed to benefit succeeding crops have also been deducted. The manurial value of home-grown foods has been neglected. No allowance is made for any seasonal variation in the quality of home-grown foods.

It has been difficult to suggest any reliable figure of the output of grass in the course of a grazing season. I have assumed that the output in these cases has averaged 1,500 lb. of starch equivalent per annum, equivalent to about 6 tons of grass per acre per annum (S.E. 11 per cent). I think that this is probably a very conservative estimate.

It will be seen that grass is far and away the cheapest source of food at the farmer's disposal and that hay has also been much cheaper than most purchased foods. Assuming that hay and grazing are complementary to one another over the year and that equal acreages are devoted to each, the joint starch equivalent costs are about 11d. per unit. We may go so far as to say that, if there is no increase in waste, higher yields of grass and hay can be produced cheaper than this figure, owing to the very high proportion of standing charges, represented by rent and other overheads, in the total cost of production.

Against these points of view must be set the convenience of purchased food. The supply of grass is unevenly distributed and is unreliable one season with another. Hanley has said that grass has three faults (1) a short season of growth ; (2) a very variable rate of growth during the season ; and (3) a gradual deterioration in quality as the season advances*. Statements have also been made which indicate that hay is capable only of providing a maintenance ration for stock.

These points are particularly important for example in an intensive milk selling system. Under modern conditions for the production of milk it is unusual for farmers not to buy foods from outside the farm. Purchased foods enable more stock to be carried than the land itself farmed to its maximum economic output is capable of carrying ; they are generally recommended as a balancing factor in rations, as enabling a regular output to be maintained against a varying home-grown food supply, and are also necessary where owing to seasonal influences the output of home-grown foods is lower than normal. If therefore we are to maintain regular production, say of milk, or obtain adequate and regular live weight gains it is not to be wondered that farmers are prepared to offset a part at least of the extra cost of purchased foods against their greater reliability and convenience.

This then seems to me to contain the germ of the place of the improvement of grassland management in present day farming, viz., that we must seek methods which will match those factors of reliability and convenience in purchased foods for which farmers are prepared to incur the extra cost. If we can make grass more reliable, get it better distributed throughout the year, if we can obtain a higher quality of conserved grass, whether as hay or in other forms, then, although the expenditure involved in obtaining these results may increase the cost per unit, it is possible that grass may still be more economical than purchased food, owing to the wide margin which exists between the costs at the present time. The scientists who are working on grassland problems are fully aware of the vital importance of removing the uncertainties of the grass crop, as evidenced by the work on early grass, rotational grazing, better quality hay and the conservation of surplus grass.

The knowledge that we can improve the supply of grass and alter the time when it becomes available is of great value as a scientific achievement. The use to which this knowledge will be put is dependent upon the market demand for grassland products and the changes which may take place for them from time to time. Early grass is of greater value to some farmers than to others and early grass may be in demand at one time and autumn grass at another. But in my case the knowledge of how to produce the best grass at any time is in itself a valuable asset.

*Hanley. Grassland problems. Conference held at Harper Adams Agricultural College. February, 1930.

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500/9/33. *Printed by the Cambrian News (Aberystwyth), Ltd.*